Journal of Forestry Research (2010) 21(4): 409–414
DOI 10.1007/s11676-010-0090-3

ORIGINAL PAPER

A case of gregarious flowering in bamboo, dominated lowland forest of Assam, India: phenology, regeneration, impact on rural economy, and conservation

Hemen Sarma • Ananta Mohan Sarma • Aniruddha Sarma • Souravjyoti Borah

Received: 2009-10-29; Accepted: 2010-03-10

Abstract: We recorded gregarious flowering of three bamboo species viz. *Bambusa arundinacea*, *Bambusa tulda* and *Melocanna baccifera* during rainy season from early March to late May, 2008 at lowland forest of Bajali area of Indo-Burma hotspot region. A regular method of field sampling of various forest types was used to map the bamboo species in Assam, India. Moreover, people's perception on bamboo blooming was investigated at 17 sample plots covering 258 respondents inhabiting at the site at an average of 15 in each plots. A floral clump (inflorescence) emerged and developed into a giant panicle comprising of numerous florets. Two types of seeds viz. bacca and caryopsis were recorded in different species. Viviparous germination was noticed in few bacca seeds produced by *M. baccifera* and this has unusual occurrence in bamboo. Seed viability test shows that 75% caryopsis seeds were viable; these seeds had the potential of germination and can be used for mass regeneration. Most local respondents believe that bamboo flowering can result in population explosion of rodent, therefore, they think bamboo flowering is positively correlated with famine. This traditional belief results in massive destruction of bamboo clumps, which significantly impacts on rural economy.

Keywords: bamboo; famine; flowering; Indo-Burma hotspot; rural economy; viviparous germination

The online version is available at http://www.springerlink.com

Hemen Sarma (✉) • Souravjyoti Borah
Centre for Advanced Studies in Botany, School of Life Science, North-Eastern Hill University, Shillong, India, 793022.
Email: hemens02@yahoo.co.in

Ananta Mohan Sarma
Department of Botany, Bajali College, Pathsala, Assam 7813 25, India.

Aniruddha Sarma
Department of Biotechnology, Pandu College, Guwahati, Assam, India.

Responsible editor: Hu Yanbo

Introduction

Bamboos are woody perennial angiosperms under the family Poaceae and some species show the peculiar habit of dying after flowering in long life cycles of two to 120 years (McClure 1966). India is one of the leading countries of the world, second only to China, in bamboo production with 32.3 million ton/year (Pathak 1989). Bamboo species cover an area of around 10.03 million hectares, which contribute 12.8% of the total forest cover of the country. India ranks the third i.e., next to China (300 species) and Japan (237 species) in diversity of bamboo species. Within India, North Eastern Hill (NEH) region possesses the largest diversity of bamboo species (Bhatt 2003). Out of 126 plant species available in India, nearly half of the species are available in this part of the country (Hore 1998).

The northeastern region of India, being rich in biodiversity, is recognized as one of the 34 'hot spots' of the world (Myer 2000). The region is inhabited by diverse ethnic groups, which have their unique lifestyles and are dependent on forests to a great extent for their subsistence (Sarma and Sarma 2008). The current status of bamboo forest and bamboo growing area in the north-eastern states of India are presented in Table 1. The state of Assam has a geographical area of 78 438 km^2, of which the area of 1 813 km^2 is covered by bamboo.

Bamboos form an integral constituent of the home-gardens in Assam (Kumar 1997). Bamboo grove is a separate zone within the home-garden or in the adjoining land parcels where bamboo is grown either in pure stands or mixed with other plants. The villagers manage these bamboo groves for commercial purposes, because the home-garden bamboos are essential for meeting the felt needs of the rural households. The farmers inhabiting Assam are subsistence-oriented and they maintain multi-strata home-gardens by planting trees, shrubs, and herbaceous plants. Bamboo is one of the more important components of the home-gardens, which provides the villagers with a wide range of goods and services (Nath and Das 2008).

Table 1. The current status of bamboo forest and bamboo growing area of northeastern India (Naithani, 2008)

State	Geographical area(km^2)	Forest area (km^2)	Percentage (%)	Bamboo area(km^2)
Arunachal Pradesh	83,743	53,932	61.50	4596
Assam	78,438	27,618	34.40	1813
Manipur	22,327	16,926	75.80	3692
Meghalaya	22,492	9,496	42.30	3102
Mizoram	21,081	15,935	75.60	9210
Nagaland	16,579	8,629	52.00	758
Tripura	10,486	6,293	60.00	939

A traditional belief among the inhabitants is that the flowering of bamboo leads to increase of rodents population, which in turn leads to famine due to huge consumption of cereal crops. Following this belief, massive destruction of flowering and non flowering clumps has been carried out. Although scattered information is available on bamboo resources of the region (Soderstrom and Calderon 1979; Sharma 1980; Sharma et. al. 1992; Singh 2002; Sarkar and Sundriyal 2002), however, no attempts have been accomplished so far to evaluate the increase in rodent population after flowering, economic impact of large scale destruction of bamboo clumps, and seed germination study for regeneration dynamics.

The objectives of this work was to study the phenology of three bamboo species bloomed in the episode of a few months during current year growth and to assess all bamboo species and their past flowering information in Assam. The secondary purpose was to study the people's perception on bamboo blooming and their destruction besides working out the possible socio-economic impact on the communities, germination of seeds for regeneration and to frame a comprehensive policy for mass afforestation and indigenous use. Three hypotheses were examined: (a) people's perceptions on increase of rodent population vis-a-vis bamboo flowering; (b) randomly destructed flowering and non-flowering clumps resulting in economic loss; and (3) regeneration of the bamboo species through seeds is adequate.

Materials and methods

Study location

Assam state in India expands between 89°42' E longitude to 96° E longitude and 24°8' N latitudes to 28°2' N latitudes, covering an area of about 78 523 km^2 (30 318 square miles) (Fig. 1) in the northeastern part of India. The state has two geographically defined area viz. Brahmaputra and Barak Valley of Indo-Burma hotspot. The altitude ranges from 30 m to 680 m a.s.l., harboring a mosaic of vegetation types.

As a regular exercise of field sampling of various forest types, we recorded the bloomed bamboo in Bajali sub-divisions (26°30'27.3" N and 91°11'041" E), within the Bengal and Assam plain eco-region. The site covers approximately 45 ha, covering 17 localities from 15 villages; the forest type classified by Champion and Seth (1968) includes semi-evergreen forest (${}_2AC_1$), secondary moist bamboo brakes (${}_2B_2S_1$), moist sal-bearing forest (${}_3C/C_2$), and northern secondary moist mixed deciduous forest (${}_3C/C_3/{}_2S_1$). This region is characterized by a hot sub-humid (moist) to humid (inclusion of per-humid) climate with alluvial dried soil and growing periods of approximately 210+ days. Mean daily temperatures range from 20°C in January to 32°C in July, and annual precipitation averages 1 600 mm.

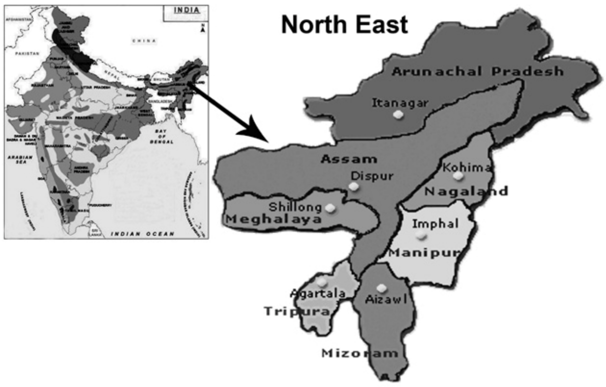

Fig. 1 Locational setup of study area, Assam, India.

Sampling procedure

The information on the diversity of bamboo species, the previous flowering cycle, and vernacular name were obtained by random field sampling in various bamboo-bearing areas throughout the state in 2007–2008 at two levels of home garden and bamboo grove. Bloomed bamboos exhibited during rainy season from early March to late May, 2008 at Bajali area. The sampled species were preserved and physical conditions of every individual were observed. The morphological characteristics of inflorescence, seeds, and the status of regeneration were also examined. All the sampled species were identified with the help of accessible literature (Seethalakshmi et al. 1998; Singh and Dey 2002; Chowdhury et al. 2005; Quattrocchi 2006) and cross referenced to collection house at Botanical Survey of India (Shillong). The botanical name was written as in International plant names index (IPNI) database.

The inhabitants of Bajali were interviewed through structured questionnaires to assess the impact of bamboo flowering on increase in rat population, the economic loss due to large scale destruction of bamboo clumps, and seedling emerging from seeds. The detailed inventory was done in 17 sample plots of 15 villages, covering 258 respondents including various age groups in different walk of life. The recorded data were statistically analyzed for interpretation using SPSS software.

Seed viability test

Seeds produced by the flowering species were collected from field; and the viability test was done in laboratory. The plucked bacca seeds were brought to the laboratory, enclosed within polyethylene bags and immediately stored in a refrigerator at a temperature ranging between 8°C and 10°C. A 50–80 μmol·m^{-2}·s^{-1} light intensity could reach the seed occasionally, whenever

the door of the refrigerator was opened for transaction. The green young seeds were found to germinate inside the refrigerator and per cent of viable seeds was calculated. Similarly the caryopsis seeds were first placed in water until the viscin layer became swollen. The swollen seeds were then placed in rows on a circular piece of filter paper and allowed to dry. Each seed was then cut in half longitudinally with sharp blade. The filter paper bearing the cut seed was then placed in a 100-mm petri dish, covered with a 0.1% solution of 2, 3, 5-triphenyltetrazolium chloride (TTC) in to an insoluble, red pigment, which was observed in the embryo and endosperm. Non-viable seeds remained unstained. Seeds showing stain were considered as viable and the viability per cent was calculated.

Results

In the present study, 42 bamboo species were inventoried from various bamboo bearing pockets of Assam through a meta-analysis, with vernacular name and last flowering information (Table 2). Almost all the species have been used in household's practices in Assam and a few important species are used in livelihood in rural Assamese society. In addition, we recorded gregarious flowering in three species namely, *Bambusa arundinacea*, *Bambusa tulda* and *Melocanna baccifera* from Bajali and people were panic with the situation exercising large-scale destruction of bamboo clumps with the range from 25% to 100% (Fig. 2).

Table 2. A list of bamboo species found in Assam, with the vernacular name and flowering cycle.

Sl. No.	Scientific name	Vernacular name	Last flowering recorded
1.	*Bambusa arundinacea* Retz.	Kotoha banh, Kata Banh, Baroowa	1996-97 in Nalbari and 2008 in Bajali, Assam (Gregarious flowering)
2.	*Bambusa assamica* Barooah *et* Borthakur	Saru Bijuli	No record
3.	*Bambusa barpatharica* Borthakur *et* Barooah	Bijuli banh	No record
4.	*Bambusa auriculata* Kurz	Kalia bans	1889 in Kamrup, Assam
5.	*Bambusa balcooa* Roxb.	Bhaluka banh	1998 in Bilasipara, Assam
6.	Bambusa burmanica Gamble	Thaikowa	1986 in N.C.Hills, Assam
7.	*Bambusa cacharensis* R.B.Majumder		
8.	Bambusa garuchokua Barooah *et* Borthakur	Garuchokua banh, Nangal banh	No record
9.	*Bambusa jaintiana* R.B.Majumder		
10.	*Bambusa multiplex* (Lour.)Raeusch ex.Schult and Schult.f	Borosi dang banh, Jupuri banh	No record
11.	*Bambusa nutans* Wall.	Jatia Makal	No record
12.	*Bambusa pallida* Munro	Bijuli	1890 in Kamrup, Assam
13.	*Bambusa polymorpha* Munro	Jama Betwa, Betwa	No record
14.	*Bambusa pseudopallida* R.B.Majumder	Bijuli Banh, Deo banh	1965 in Assam
15.	*Bambusa rangaensis* Borthakur *et* Barooah	Bon-bijuli	No record
16.	*Bambusa teres.* Buch.-Hem.	Bhaluki makal	1998 in Western Assam
17.	*Bambusa tulda* Roxb.	Jati Banh	1997 in Sporadic flowering in Dhemaji and Lakhimpur 2008 in Bajali(Gregarious flowering)
18.	*Bambusa vulgaris* Schrader var. *vulgaris*	Tanti banh, Telai Banh	No record
19.	*Bambusa vulgaris* Schrader ex var. *striata* (Lodd.) Holttum	Halodhia banh	No record
20.	*Bambusa vulgaris Schrader* var. *waminii* (Brandis)Wen	Kolochi banh	No record
21.	*Chimonobambusa callosa* (Munro.) Nakai	Uspar	No record
22.	*Dendrocalamus gigantius* Munro.	Kako, wara	No record
23.	*Dendrocalamus hamiltonii* Nees and Arn ex Munro.	Pahari kako, Kekowa	No record
24.	*Dendrocalamus hookeri* Munro.	Sait, Sejsai, Sijong uktong, ussey	1950, 1967 and 1982 in Khasi hills, Shillong
25.	*Dendrocalamus longispathus* Kurz	Khang	No record
26.	*Dendrocalamus patellaris* Gamble	Futung (Karbi)	No record
27.	*Dendrocalamus Strictus* Nees	Shal banh	No record
28.	*Dinochloa mclellandii* (Munro) Kurz	Bel bah, Lota banh	No record
29.	*Gigantochloa albociliata* (Munro) Kurz	Kalisundi	No record
30.	*Gigantochloa macrostachya* Kurz	Tekserah (Garo)	1889 in Garo hills
31.	*Gigantochloa rostrata* Wong	Pani banh	No record
32.	*Melocalamus compactiflorus* Benth.	Beti banh	No record
33.	*Melocalamus indicus* Majumder	-----------	No record
34.	*Melocanna arundiana* Parkinson	-----------	No record
35.	*Melocanna baccifera* Kurz	Terai, Muli	2008 in Bajali (Gregarious flowering)
36.	*Oxytenanthera parviflora* Brandis ex Gamble	Hill Jati	No record
37.	*Phyllostachys assamica* Gamble ex Brandis		No record
38.	*Phyllostachys manii* Gamble	Deo banh	No record
39.	*Schizostachyum dullooa* (Gamble) R.B.Majumder	Dolo banh, Dullo	No record
40.	*Schizostachyum griffithii* (Munro) R.B.Majumder	Beti banh	No record
41.	*Schizostachyum pergracile* (Munro) Majumder	Medang banh	No record
42.	*Schizostachyum polymorphum* (Munro) R.B.Majumdar.	Bojal bah, Nal banh	1978, 1979 in Mizoram.

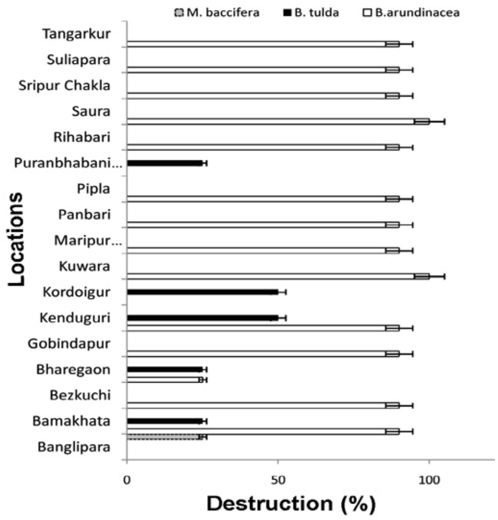

Fig. 2 Destruction of bamboo clumps (March to May 2008) at Bajali by the inhabitants in apprehension of impending famine. Error bar are the percentage.

A floral clump (inflorescence) emerged from the rhizome and developed into a giant panicle. The branching pattern was similar to that of vegetative culms. Many floral buds were arranged distichously in tight capitate-wise clusters of spikelets or pseudospikelets at base of the nodes. Young inflorescences were developed in the early stages, and within a few weeks whole clumps were transformed into giant inflorescences (Fig. 3*a*).

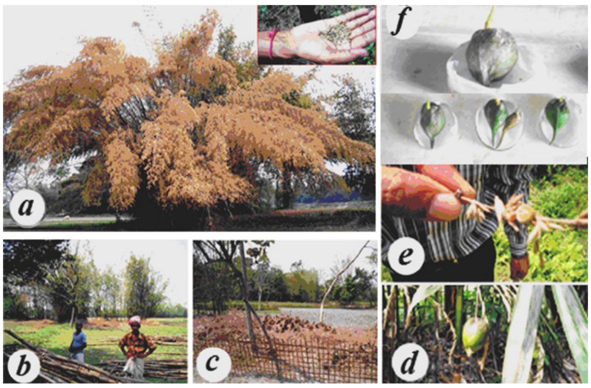

Fig. 3 One flowering clump of bamboo, showing entire clump has transformed into a huge inflorescence (*a*); massive destruction of young bamboo clump after flowering (*b, c*); bacca seed following vivipary germination (*d*); caryopsis with an inflorescence (*e*); germination potential of bacca seeds examined in laboratory (*f*).

In the present study, we observed morphologically two dissimilar seeds in flowering species. In *B. arundinacea* and *B. Tulda*, the seed type was caryopsis and the seed size was about 5 mm to 8 mm in length with large starchy endosperm and furrowed on one side. Dissection of seeds showed embryo and part of the endosperm being close to the embryo. About 75% caryopsis seeds showed insoluble, red pigment in the embryo and endosperm region at laboratory. These seeds had the potential of germination and can be used for mass regeneration. On the other hand, an indehiscent fruit derived from a single ovary having one or many seeds within a fleshy wall or pericarp (bacca) produced by *M. baccifera.*

The seedlings emergence at natural habitat beneath the flowering clumps signify the natural process of regeneration and some of these seedlings had variegated leaves. In *M. baccifera*, the peculiar viviparous germination was observed (Fig. 3*d*) where seeds germinate within the fruit, followed by subsequent embryo development before the seeds are dispersed from the parent plant. Vivipary has been reported in less than 100 flowering plant families representing less than 0.1% of angiosperms (Farnsworth 2000). The best known cases of vivipary in angiosperms are documented in mangroves of Rhizophoraceae and Avicenniaceae (Cota-Sánchez 2004). On the other hand, 80% seed viability of *M. baccifera* was recorded, showing regeneration dynamics under stress full condition in laboratory. Although we do not have a conclusive explanation for this phenomenon in *M. baccifera*, presume that various intrinsic and extrinsic factors such as physiology, temperature, and high humidity may be involved.

The result would be an addition to such relevant information available on these bamboos and represents the first report of massive destruction in apprehension of impending famine due to gregarious flowering. Of 17 locations, the maximum destruction had been reported for 14 sites where *B. arundinacea* bloomed during the current year growth, followed by *B. tulda* in five locations and *M. baccifera* in one location.

A total 258 respondents interviewed expressed their view on population explosion of rodent due to bamboo flowering. Mean positive response percent was only 13.88%, which is depicted negative correlation between bamboo flowering and famine (Table 3). Almost half of the all respondents (52.98%) have noticed juvenile seedling emergence at the site irrespective to age groups (Fig. 4). Particularly the maximum small bamboo base entrepreneur faced economic constraints due to massive destruction and showed 84.62% positive response to financial impact of gregarious flowering. This has proved that randomly destructed flowering and non-flowering clumps resulted in economic loss.

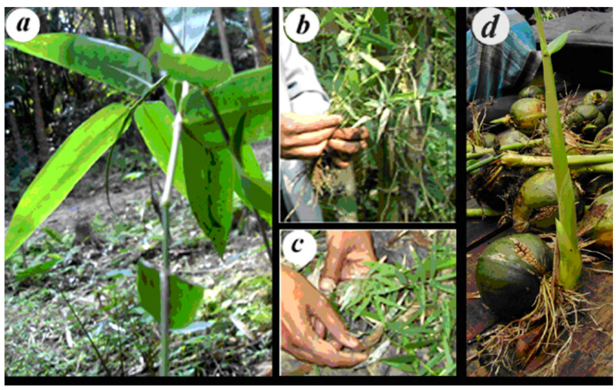

Fig. 4 A young bamboo seedling developed from seed falling on the ground (*a*); An uprooted seedling (*b, c*); A young bamboo seedling developed from bacca seed (*d*)

Discussion

The mechanisms of bamboo flowering and death are still not well known, which may involve in pathological, periodical, mutational, nutritional, human resource matching, predator satiation reasons, and bamboo wildlife cycle hypothesis (Prasad 1990). Physiologically, the flowering mechanism of bamboos differs significantly from other vegetation. Generally, most of the bamboo species flower gregariously at fixed intervals and all clumps would die after flowering. The flowering is synchronous and this phenomenon is called gregarious flowering. The gregarious flowering has been observed to occur at regular time intervals (Seethalakshmi et al. 1998). Such a peculiar behavior of bamboos often creates ecological, economic, and social problems, particularly in the northeastern India.

Table 3. Respondent's summary of total variables in 17 locations of 15 villages. The frequency of samples is 15 in each site.

Respondents	Age group	Percentage of total respondents (%)	Notice seedling germination (%)	Record the increase of rodent population (%)	Positive response to financial impact (%)
Small bamboo base entrepreneur	35 - 60	10	23.07	7.69	84.62
Farmers	40 - 60	45	46.55	5.17	93.96
Elderly person	65 - 75	25	75	23.44	90.62
Bamboo product manufacturer	50 - 70	20	67.31	19.23	92.31
All Respondents	Mean		52.98	13.88	90.37
	SD±		23.28	7.65	4.07
	CV%		227.57	181.43	22230.29

Many traditional beliefs are associated with bamboo flowering. In Alappuzha district of south India, local people burn down the flowered clumps of *Bambusa vulgaris* because of a traditional belief (Koshy and Harikumar 2000). Similarly in northeast India, people believe that bamboo flowering is the indication of famine as gregarious flowering of bamboos produces large quantities of seeds and the consumption of fruits by rodents resulting in their population explosion which in turn leads to famine. About 11-m^2 clump of Indian *Dendrocalamus strictus* can produce 320 pounds of seeds (Deogun 1936).

The incidences of bamboo flowering and famine may not be a myth but a real happening. Many rats, though nocturnal, were found to be feeding on bamboo seeds even during mid-day, resulting in population explosion and establishing the dynamic interaction (John and Nadgauda 2002). In the present study in Bajali, only (13.88 ±7.65)% respondents noticed the increase in rodent population, and this has failed to draw a similar conclusion on such relationship.

The gregarious flowering results in sudden availability of huge stockpile of dry bamboos- a big fire hazard. The people dependent on bamboo for livelihood purposes deprived of the source materials and fear of outbreak of an epidemic. Bamboo flowering is a recurring natural phenomenon in the local, its effective control is essential for sustainable management of bamboo forest of the region. Extension and awareness program should be undertaken on priority basis by adopting a pragmatic policy to conserve the bamboo resource.

In the riverine areas of Kaldia and Pohumara rivers, massive destruction of bamboos was observed during study period, which may lead to soil erosion, further cause detrimental effects on environment. Bamboo plantation in those areas will act as remedial measures for soil conservation, watershed development, reclamation of wasteland, and stabilization of embankments to some extent.

Tribal communities of the region use bamboo resource for food, shelter, furniture, handicraft, medicines, and various ethno-religious purposes (Marden and Brandenburg 1980; Tewari 1992). This resource has also been considered valuable for agro forestry owing to its short gestation period and recurring return (Singh et al. 2001).

In India, biological species of bamboos are closely interlinked with religious and other cultural traditions, which have resulted in co-evolution of cultural traditions with selection of wild plant species. Bamboo has been an integral part of the cultural, social, and economic status of Assam. Bamboos have been nurtured and protected for the local livelihood and various functional uses. The local people, thus, have some knowledge and skills about the propagation, processing, and usage of bamboos.

Bamboo products can be seen everywhere in Assam. Bamboo baskets of innumerable types and shapes are used for various purposes. For example, bamboo culms are used as containers for storing home-brewed rice beer, for fetching water, and for carrying drinking water. Bamboo houses are characterized by walls, having a framework of wood and bamboo matting. Fishing implements *Jakoi, Khaloi, Juluki, Pollo,* are also made by bamboo. *Chalani* (sieve), *Kula* (winnowing fan), *Khoralu* (small basket), *Dukula* (big basket), *Doon* and *Dhol* (measuring baskets), fishing traps, hats used by the peasants in the fields are the products of bamboo. Bamboo stems are used to make musical instruments like *Banhi* (flute). The *Japi,* the traditional sun-shade continues to be the most well-known one of bamboo items. Visitors are traditionally welcomed with *Japi*, decorated with colourful design and motifs. More than 1 500 applications of bamboo have been documented, of which major ones include use as building material, agriculture and paper, and pulp (Kishwan and Goyal 2006).

The destructions of flowering and non-flowering clumps due to gregarious flowering caused scarcity of raw material, and thus most of small bamboo base entrepreneur had faced economic constraints. This has proved economic loss caused by randomly destructed bloomed bamboo species in apprehension of impending famine. The study established that increase of rodent popula-

tion vis-a-vis bamboo flowering is unscientific and there is no relation with famine.

Conservation implications and conclusions

The present study ascertained fear of famine, leading to destruction of bamboo species by the villagers. As the bamboos have the peculiar habit of dying after flowering just once, the seeds obtained in limited quantities could be used as planting material for mass regeneration. Moreover, a planned experiment is required to study the growth, development, and production efficacy of these seedlings. Considering the ecological significance and vast economic potential of bamboos in the region, bamboo flowering policy should be adopted by the government for sustained productivity and environmental security. Moreover, bamboo is an important component of agro-forestry to generate income and to meet the contingency need of rural households in the region; therefore it is an urgent need for a detailed resource survey and mapping of the bamboo resources of the northeastern states. Past flowering records, identification and grading of all bamboo-bearing areas should be recorded on priority basis.

Acknowledgements

The data used in this paper emanate from an awareness program of bamboo flowering conducted by the authors. We thank to Mr. J Das, Divisional Forest Officer, (Social Forestry), Govt. of Assam, Guwahati to facilitate the work at Bajali. We thank the Assam Forest Department for access to the site and records, Dr. C. M. Sarma for all-round support, Mr. Jintu Sarma for field guidance and Mr. Gautam Sarma for reading the first draft and for technical assistance.

Reference

Bhatt BP, Singha LB, Singh K, Sachan MS. 2003. Some commercial edible bamboo species of North East India: Production, indigenous uses, cost-benefit and management strategies. *The Journal of the American Bamboo Society,* **17**: 4–20.

Champion HG, Seth SK. 1968. *A Revised Survey of Forest Types of India.* New Delhi : Government of India Publication. 404 pp

Chowdhury S. 2005. *Assam's Flora (Present Status of Vascular Plants).* Assam: Science Technology and Environment Council. 368 pp

Cota-Sánchez JH. 2004. Vivipary in the Cactaceae: Its taxonomic occurrence and biological significance. *Flora - Morphology, Distribution, Functional Ecology of Plants*, **199**: 481–490.

Deogun PN. 1936. The silviculture and management of the bamboo (*Dendrocalamus strictus*). *Indian Forest Research,* **2**: 75–173.

Farnsworth E. 2000. The ecology and physiology of viviparous and recalcitrant seeds. *Annual Review of Ecology and Systematics,* **31**: 107–138.

Hore DK. 1998. Genetic resources among bamboos of north eastern India. *Journal of Economic Taxonomic Botany,* **22**: 173–181.

John CK, Nadgauda RS. 2002. Bamboo flowering and famine. *Current Science,* **82**: 261–262.

Koshy KC, Harikumar D. 2000. Does *Ochlandra scriptoria* flower annually or once in a lifetime? *Current Science,* **79**: 1650–1652.

Kishwan J, Goyal AK. 2006. Gregarious flowering in bamboo in northeast India. Need for intensive management. *Indian Forester,* **132**: 525–533.

Marden L, Brandenburg J. 1980. Bamboo–the giant grass. *National Geographic,* **158**: 503–528.

McClure FA. 1966. *Bamboos-A Fresh Perspective*. Cambridge, MA: Haward University Press

Myer N, Muttermeier RA, Muttermeier CA, da Fornseca GAB, Kent J. 2000. Biodiversity hotspots for conservation priorities. *Nature*, **403**: 853–858.

Nath A J, Das AK. 2008. Bamboo resources in the home gardens of Assam: A case study from Barak valley. *Journal of Tropical Agriculture,* **46**: 58–61.

Naithani HB. 2008. Diversity of Indian bamboos with special reference to northeast India. *Indian Forester,* **134**:765–788.

Pathak PS. 1989. Bamboo resources in the world. In: *Proceeding on Silviculture and Management of Bamboo*. Jabalpur, India: Institute of deciduous forests, 78-87 pp.

Prasad R. 1990. Bamboo (*Dendrocalamus strictus*) resources of the outer Himalayas and Siwaliks of Western Uttar Pradesh: A conservation plea for habitat restoration. In: I.V. Ramanuja Rao; R. Gnanaharan and C.B. Sastry, (eds), *Bamboos Current Research.* Proceedings of the International Bamboo workshop, Cochin, India. pp 34-38.

Quattrocchi U. 2006. *CRC World Dictionary of Grasses: Common Names, Scientific Names, Eponyms, Synonyms, and Etymology*. London: CRC Press, 2408 pp.

Sarkar J, Sundriyal RC. 2002. Indigenous uses, management and conservation of bamboo resource in Arunachal Pradesh, North East India. *Bamboo Journal,* **19**: 24–39.

Sarma H, Sarma CM. 2008. Alien traditionally used plants species of Manas Biosphere Reserve, Indo-Burma hotspot. *Zeitschrift Fur Arznei and Gewurzpflanzen*, **13**: 117–120.

Seethalakshmi KK, Muktesh Kumar MS, Sankara P.K, Sarojam N. 1998. *Bamboos of India: a compendium.* Bamboo Information Centre-India: International Network for Bamboo and Rattan, BRILL. 342 pp

Sharma BD, Hore DK, Pandey G, Wadhwa BM. 1992. Genetic resources of bamboos in the northeastern region of India. *Indian Journal of Forestry,* **15**: 44–51.

Sharma YML. 1980. Bamboos in Asia-pacific region. In: G. Lessard and A. Chouniard (eds), *Proceedings on Bamboo Research in Asia*. Singapore. pp. 99–120

Singh KA. 2002. Boon of bamboo resources in north-east India. In: K. A. Singh (ed), *Resource Management Perspective of Arunachal Pradesh*. Arunachal Pradesh Centre: ICAR Research Complex for NEH Region. pp 69–112

Singh MP. 2002. *Plant Biodiversity and Taxonomy*. India: Daya Books, 260 pp

Singh SK, Dhiman KR, Datta M. 2001. *Agroforestry research and practices: An overview.* In: N. D. Verma and B. P. Bhatt (eds), Steps Towards Modernization of Agriculture in NEH Region. Umiam, Meghalaya: ICAR Research Complex for NEH Region. pp 365–392

Soderstrom T, Calderon CE. 1979. A commentary on the bamboos (*Poaceae*: *Bambusoideae*). *Biotropica,* **11**: 161–172.

Tewari DN. 1992. *A Monograph on Bamboo.* Dehradun, India: International Book Distributors, 498 pp.